# Applying Seattle's Blueprint to Assess and Benefit Chinook Salmon using the Urbanized Shoreline

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## Abstract
How are threatened or endangered species managed within an urban city? To answer this for chinook salmon, listed as threatened under the Endangered Species Act, the City of Seattle developed a framework called the Urban Blueprint. The city was geographically divided into five distinct regions based on water body type. Each type requires different assessments and actions to benefit chinook salmon. The marine shoreline, or nearshore, is one geographic category and has been identified as a habitat used by juvenile chinook. However, when and how juvenile chinook use the shoreline and its resources is uncertain. As a local government, Seattle is conducting research to better manage our shoreline for chinook. Scientists at the University of Washington are working with Seattle to address the null hypotheses, juvenile chinook salmon use all marine nearshore habitats equally. The first phase, conducted this summer, developed new sampling techniques for various shoreline habitat types, including large rock beaches, riprap, vertical bulkheads and over-water docks. Next, the shoreline will be grossly classified and sampling locations picked from these classifications. Sampling will occur in the summer. The results will have broad implications to other marine shoreline areas within, at least, Puget Sound.

## Summary
How are threatened or endangered species managed within an urban city? To answer this for chinook salmon, listed as threatened under the Endangered Species Act, the city of Seattle (Seattle) developed a framework called the Urban Blueprint. Seattle was geographically divided into five distinct regions based on water body type and each type assessed separately for actions to benefit chinook salmon. The marine shoreline, or nearshore, is one geographic category and it has been identified as a habitat used by juvenile chinook. However, when and how juvenile chinook use the shoreline and its resources is uncertain. As a local government, Seattle is conducting research to better manage its shoreline for chinook. Scientists at the University of Washington are working with Seattle to address the null hypotheses; juvenile chinook salmon use all marine shoreline habitats equally. The first phase, conducted the summer of 2002, developed new sampling techniques for various shoreline habitat types, including large rock beaches, riprap, vertical bulkheads and over-water docks. Next, the shoreline will be grossly classified and sampling locations picked from these classifications. Refined sampling will occur in the summer of 2003. The results will have broad implications to other marine shoreline areas within Puget Sound and the Georgia Basin region.

## Objective
This paper presents a summary of work by many people to assess actions for the protection and restoration of chinook habitat along the Seattle marine urban shoreline. The information is taken from the marine shoreline discussion in *Seattle's Urban Blueprint for Habitat Protection and Restoration*, developed by the Seattle's City Science Team (City of Seattle 2001), and recent sampling method information developed by the University of Washington (Toft et al. 2003). By developing a structured scientific approach, Seattle is seeking to adapt the actions it takes, whether of a public investment or regulatory nature, to most effectively improve the survival of chinook salmon, a species that utilizes its shorelines. Seattle is committed to cost-effective recovery of sustainable, healthy, harvestable salmonid stocks throughout Puget Sound. Protecting and restoring necessary habitat functions both within and outside Seattle is important, and Seattle seeks to contribute its fair share regionally toward salmonid recovery. Seattle intends to do a variety of strategies, such as habitat restoration and acquisition, incentive programs, and regulations to achieve these goals and to work in partnership with stakeholders to develop proposals for applying these strategies where there are significant benefits to salmonids based on sound science.

## Description of Seattle Shoreline
The marine shoreline, estuary and freshwater areas located within Seattle provide important habitat for chinook salmon, a federally listed fish species under the Endangered Species Act. Chinook salmon are dependent on habitat conditions present in Seattle's aquatic environments, since they can be important for adult upstream migration, juvenile outmigration and juvenile rearing. In focusing on chinook and to develop a scientific framework, Seattle was divided into five ecologically distinct geographic areas:

- Lake Washington
- Ship Canal/Lake Union
- Hiram M. Chittenden Locks
- Duwamish estuary and the marine shoreline in Puget Sound

The marine shoreline area includes approximately 30 miles along the Seattle city limits, which is within two watershed basins (Water Resource Inventory Area (WRIA) 8 and WRIA 9). Approximately 8 miles of shoreline is within Elliot Bay and 2.5 miles within Shilshole Bay. The marine shoreline environment in Puget Sound possesses an extremely productive and dynamic ecosystem. Tides, currents, wave action, and intermixing of salt with freshwater create a complex physical environment situated at the juncture between land and water. For city efforts, the marine shoreline encompasses the area from upland bluffs, banks, and beaches, to the lower limit of the photic (light penetration) zone, which varies with season and climate conditions. Some define the lower limit of the photic zone as approximately 100 feet below the mean lower low water (MLLW) line. The marine shoreline area includes a wide variety of upland, marine, and estuary habitats including marine riparian areas, backshore areas, beaches, tidal marshes, tidal flats, eelgrass meadows, kelp forests, and exposed habitats. Terrestrial habitats along the shoreline such as the bluffs, sand spits, and coastal wetlands are also included within the marine shoreline environment. The marine shoreline environment also includes the tidally influenced region found within the lower sections of the Ship Canal, the Duwamish River and small streams.

Human alteration to the marine shoreline environment has been occurring in Seattle since at least the late 1800s. These activities included extensive filling within Elliot Bay and other areas to increase Seattle's land base, construction of a new outlet from Lake Washington, bank hardening along a significant portion of the shoreline areas for a railroad right-of-way and for property protection, and construction of commercial piers and marinas. The combination of these historic habitat losses and the cumulative impacts of urban development have resulted in major changes to the shoreline environment and the marine shoreline ecosystem. Relatively little is known about the direct effects of urban development and other human impacts on the migration, growth, survival, and habitat of chinook salmon in the marine shoreline areas of Seattle. However, bulkheading, bank armoring, and other human activities within shoreline areas have affected many physical processes including reductions in sediment input, transport and deposition; changes in substrate composition; and loss of riparian vegetation. These processes are important for forming and maintaining habitats that have existed in the past, including that for juvenile chinook salmon.

## The Scientific Process Approach

Seattle's scientific framework involves a number of steps. The first is to define how fish use the urban landscape based on current knowledge and expert judgment. The life history stages that each area supports are also identified. The understanding of linkages between salmon needs, habitat that provides for those needs, and landscape processes that form the habitat are described. Research is conducted to fill in key data gaps, so that information can be used for actions taken or permitted by Seattle. The importance of marine shoreline areas to chinook salmon is poorly understood. Research is needed to address how, and to what extent, specific shoreline areas influence the survival, growth, and condition of Puget Sound chinook. Key marine shoreline research and assessments include: (1) determination of the presence, distribution, and periodicity of juvenile chinook within marine shoreline and estuary habitats; (2) identification of preferences in shoreline areas by juveniles and sub-adults for specific types of habitat; and (3) identification and evaluation of the use of specific shoreline areas within Seattle by forage fish species used by subadult and adult chinook.

## Chinook Salmon and the Urban Seattle Marine Environment

Shoreline marine and estuary environments provide important habitats to several life stages of chinook salmon, including subadult, adult and juveniles. Adult chinook returning from the ocean migrate through shoreline areas prior to entering freshwater to spawn (KCDNR 2001). Juvenile chinook that have recently outmigrated from freshwater habitats have been found along marine shorelines. Moreover, the shoreline environment provides essential spawning and foraging areas for baitfish including herring, surf smelt, sand lance, and shiner perch upon which subadult and adult chinook feed.

Puget Sound chinook, including those from the WRIAs 8 and 9 watersheds are "ocean type" chinook, meaning that they spend less time rearing in fresh water and outmigrate to saltwater as smaller fry (Myers et al 1998). The period of use within estuary and marine shoreline areas of Seattle may be highly variable among individual juvenile fish. Shepard (1981) found that some individual chinook may utilize estuarine and shoreline habitats for as few as four days, while other authors have documented that juvenile chinook use estuary habitats for up to 189 days (Wallace and Collins 1997; Levy and Northcote 1982).

It has been hypothesize that marine riparian areas provide functions similar to freshwater riparian areas and may provide additional roles unique to marine systems. Riparian corridors provide food sources in the form of insects dropping into the water and also provides shade to smelt spawning beaches. A loss of riparian vegetation results in a reduction in food resources for foraging in the shoreline environment. Loss of riparian vegetation along the shoreline may decrease the productivity of deeper water habitats by decreasing detrital inputs. Almost all native coniferous forests along the Seattle shoreline have been removed. Shoreline riparian areas are generally limited to landscaping in parks and residential areas and remnant deciduous forests growing on bluffs and steep slopes along the few remaining natural shoreline areas.

Juvenile chinook salmon in the marine shoreline and estuary areas of central Puget Sound tend to be closely associated with shallow habitats located close to shore (KCDNR 2001). This is consistent with observations in other regions of the Pacific northwest, where juvenile chinook are found to be strongly associated with shoreline areas (Levings et al. 1983). Marine shoreline areas and estuaries may be particularly important for juvenile chinook salmon for migration, feeding, and rearing within the central Puget Sound (KCDNR 2001). Moreover, some of these areas are used by juveniles for the physiological transition from freshwater to saltwater, especially from mouths of rivers and small streams. Many factors, such as the distribution and abundance of predators, food availability, tides, river flows, and genetics may affect how and when juvenile salmonids use and migrate through the marine shoreline and estuary areas of Seattle.

Because Puget Sound chinook outmigrate as younger and smaller juveniles, they are more dependent on forage in the estuaries and marine shoreline systems to increase their body weight and condition before moving into more pelagic environments (i.e., deeper Puget Sound waters or the Pacific Ocean) (Levy and Northcote 1982; Pearce et al 1982). The results of beach seine sampling indicate that juvenile chinook are abundant in shallow shoreline areas including intertidal flats, eelgrass meadows, tidal marshes, and shallow subtidal channels near estuaries (KCDNR 2001). The shoreline environment supports populations of several important prey species utilized by juvenile, sub-adult, and adult chinook. Young salmon are opportunistic feeders with diets that vary considerably (Healy 1982). While in the shoreline, juvenile salmonids prey on an array of benthic, epibenthic, and pelagic organisms (Fresh et al 1981). Prey species vary depending on the estuarine or shoreline habitat type and the size of the fish. Shoreline areas also provide habitat for fish species that serve as prey for subadult and adult chinook. Surf smelt, longfin smelt, Pacific sand lance, eulachon, and Pacific herring are major forage fish. Habitat impacts on forage fish (baitfish) within Seattle may have a greater effect on sand lance and surf smelt populations than other forage fish species. Sand lance commonly spawn within the Seattle shoreline. Surf smelt also spawn along several beaches within the Seattle shoreline. Surf smelt and sand lance have specific spawning habitat requirements, which make them especially vulnerable to shoreline development activities (Lemberg et al 1997; Pentilla 1978; Pentilla 2000). These activities can result in change in beach elevations and substrate composition, which are critical factors for baitfish spawning. Resulting loss of overhanging riparian vegetation along shorelines may reduce shading and result in reduced survival of these species' eggs and larvae (Pentilla 2000).

## Urban Methods Being Implemented

Along the marine shoreline, Seattle and others, such as the Port of Seattle, are pursuing several methods of addressing chinook salmon recovery within the urban area. Habitat restoration is integrated with water-dependent development and projects. In Elliot Bay, construction of the Bell Harbor Marina included a reduced slope shoreline for juvenile salmon and construction of the Olympic Tug and Barge pier included grated decking in the pier design for light penetration into the water below the pier.

Marine shoreline needs are considered in planning and design of drainage and sewer capital improvement projects. An example is the consideration of rerouting Wolfe Creek surface-water runoff from the sewer treatment system to the Shilshole Bay estuary. Big capital projects like reconstruction of the Elliot Bay Seawall, which is a horizontal bulkhead, provide an opportunity to include fish-friendly elements. In support of a community group, Groundswell Northwest, Seattle contributed funding with WRIA 8 and other agency grant programs, to purchase the Salmon Bay Natural Area in Shilshole Bay. Key marine shoreline research is also being conducted.

## 2002 and 2003 Marine Shoreline Research

Although previous sampling studies indicate that juvenile salmon are present along Seattle shorelines, there is little specific information about whether or not juvenile salmon preferentially use (or avoid) certain types of Seattle shorelines, and what functions the different types of shoreline provide for them (Seattle Public Utilities, 2001). Based on research conducted in other areas, it is believed that small juveniles of pink, chum, and chinook salmon prefer shallow areas along estuarine and marine shorelines, including beaches and eelgrass beds. However, in urban settings, it is unknown if the juvenile salmon select more "natural" and avoid more "developed" areas of the shoreline environment, or alternatively,

if they are simply randomly distributed along the shoreline. In addition, residence time in the various shoreline habitats is unknown. A study was conducted by the University of Washington in 2002 and will be continued in 2003. The purpose of the 2002 study was to develop and test a variety of sampling methods to design statistically based studies for comparison of abundance, residence time and behavior of juvenile salmon along city of Seattle shorelines. Most prior sampling for juvenile salmon in the region has been conducted using beach seines, which are only effective for sampling certain habitat types such as shallow beaches at certain tide levels. Results of 2002 phase one efforts have been used to recommend 2003 sampling methodologies. Linking the methodology results with city marine shoreline habitat classification, the hypothesis "there is no significant difference in juvenile salmon abundance among city of Seattle shoreline types" will be tested. Statistically rigorous results are important to resource managers who need to identify potential impacts of shoreline activities on salmon, prioritize recovery actions, and identify approaches that provide maximum protection to those shoreline marine areas that are important to juvenile salmon. Juvenile salmon may be subsampled (e.g., presence, diet composition) for indication of how of habitat types might be used.

As mentioned above, the goal of the 2002 sampling was to develop and test sampling methods and approaches that are effective for sampling different habitat types and to gather information about what types of sampling methods are effective for fish using different parts of the shoreline (e.g., differences in water depth used among different species and or life history stages). The sampling methods used were enclosure nets, underwater videography, snorkel surveys and above-water observations. The types of habitats sampled were a shallow cobble beach, a rip-rapped marine breakwater, an over-water structure, a shallow sandy beach, an exposed or high energy shallow sloped beach, and a steep seawall. The last three sites were only sampled once. The 2002 study was not a quantified stratified sampling design, so statistical tests comparing different habitat types were not included. The 2002 study results provided criteria demonstrating the effectiveness or lack thereof of the different sampling techniques and whether each method does or does not effectively meet the intended sampling purpose. The effective shoreline sampling methods were with an enclosure net and by conducting snorkel surveys.

The University of Washington will conduct the second phase of the study in 2003. Sampling methods to be used are enclosure nets and snorkel surveys. Sampling site types and locations were selected based on habitat types within the Seattle marine shoreline. To characterize the Seattle shoreline, the Washington Department of Natural Resources ShoreZone Inventory (WDNR 1999) was used as a starting point. A British Columbia shoreline classification system contained within this database was also used. Color orthophotography and field checks were also used to select sampling sites. Part of the sampling design includes some paired sites, to compare differences between types of habitats within close proximity. The University of Washington will publish results of this study after the 2003 sampling and data analysis.

As Seattle continues in partnership with others, actions will be based on research results and monitoring will be conducted. With approaches adjusted based on monitoring results and new knowledge, over time the effectiveness of Seattle's actions should improve.

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